

5. FISHERIES

To address concerns about potential impacts of the Aqueduct's discharge of solids on key anadromous and resident fish species, several lines of investigation were carried out. A list of species of concern was developed and discussed with key resource agencies. Life history data, particularly critical life stages and habitat requirements, were compiled for species of concern (Section 5.1). A qualitative evaluation was conducted by EA staff of potential fish habitat in the project area (Section 5.2), and potential impacts of sediment discharges to species of concern were evaluated (Section 5.3). Based on these studies, discharge management scenarios were developed that could minimize potential impacts to fisheries resources that may be at risk (Section 5.4).

5.1 LIFE HISTORY INFORMATION

Information in this section on life history and general distribution was compiled from major fisheries and Chesapeake Bay resources compendia including Lippson (1973), Lippson and Lippson (1984), U.S. Fish and Wildlife Service (1978), Lee et al. (1980), Funderburk et al. (1991), Cooper et al. (1994), and Jenkins and Burkhead (1994). References to recent occurrence and abundance are based on the District of Columbia Department of Health, Fish and Wildlife Division (DHFWD) file data.

The species discussed include those listed in the EPA-approved Study Plan dated 24 June 1999, which was negotiated with input from EPA Region III, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the D.C. Department of Health's Fish and Wildlife Division. In addition, the Federally endangered shortnose sturgeon (*Acipenser brevirostrum*) was included because of concerns regarding its possible occurrence in the project area.

5.1.1 Striped Bass (*Morone saxatilis*):

General

The striped bass is assigned to the family Percichthyidae, a loosely allied group of species that occur worldwide and are commonly referred to as the temperate basses. Striped bass grow to relatively large size. Sexual maturity of adults occurs at greater than 500 mm in length, and maximum sizes have been reported of 1,156 mm (males) and 1,829 mm (females). A maximum weight of 56.7 kg (125 lb.) was reported. Post-yolk sac larvae feed on zooplankton; juveniles feed on insects and other invertebrates and fish larvae; and adults consume primarily fish. The

striped bass has historically been one of the most important commercial and recreation finfish species in Chesapeake Bay. A long-term decline in species abundance in the 1970s and 1980s was addressed with a fishing moratorium in the 1980s, and the species rebounded and again supports lucrative commercial and sport fishing interests.

Distribution

The striped bass is an anadromous species that naturally occurs from Canada south to northern Florida, and from Florida to Louisiana in the Gulf of Mexico. It has successfully been transplanted to the west coast. The Chesapeake Bay is the most important spawning and nursery ground on the Atlantic coast. Within the Bay there are 11 general spawning regions, including the tidal freshwater Potomac River. Adult and juvenile bass may be found anywhere in the Bay, and some, particularly juveniles, may stay in the Bay for several years before migrating to oceanic waters.

Habitat Requirements

Proper water temperatures are important to all life stages of striped bass. Temperatures ≤ 12 C are considered lethal to eggs and larvae. Historically, there have been a number of catastrophic mortalities of eggs and larvae in Bay rivers when cold snaps pushed water temperatures below 11 or 12 C. Larvae can tolerate temperatures of 12-23 C, but 18-21 C is optimum. Upper lethal limits for larvae have been reported as low as 28.9 C. Juveniles grow best at 24-26 C, and growth is greatly reduced at 30 C. The physiologically optimum temperature decreases as striped bass grow: 26 C for first year juveniles, 20-24 C for second year juveniles, and 20-22 C for adults. Based on several studies, dissolved oxygen (DO) concentrations of 5 mg/L or greater are considered necessary for protection of all life stages. Although striped bass spawn primarily in fresh water, salinities of 3-7 parts per thousand (ppt) were shown to enhance growth and survival of the young. Suspended solids concentrations of 500-1,000 mg/L can reduce hatching success and/or reduce survival of larvae. Striped bass larvae are very sensitive to acidic pH. Values as high as 6.5 have been reported to be lethal. Juveniles are a little more resistant. A pH range of 7.0-9.5 is recommended for striped bass culture.

Spawning

Striped bass spawn in tidal freshwater when water temperatures are between 14.4 and 21.2 C, with peak spawning between 17.8 and 20.0 C (Figure 5-1). The duration of spawning is variable, depending on environmental conditions. It can take place from five to nine weeks in the

Potomac River, generally from April into June, but in any given location the duration is likely shorter. Based on Potomac River temperature data for the last four years, the peak of spawning in the Potomac River was likely during the first half of May (Figure 5-1). Spawning takes place over bottoms of sand or mud, with some current. Eggs hatch in 48 hours at 17-20 C. The larval stage lasts approximately one month. Although Whitestone Point, approximately 20 miles downstream of the Washington Aqueduct study area, is reported to be the upstream-most limit of spawning in the Potomac River (Funderburk et al. 1991), spawning cannot be ruled out for the Aqueduct study area. Sampling by DHFWD from early April to late May 2000 upstream of Key Bridge yielded 149 striped bass including mature fish ranging in size up to 1,125 mm.

5.1.2 White Perch (*Morone americana*):

General

The white perch also belongs to the family Percichthyidae, or temperate basses. It is closely related to other *Morone* species such as the striped bass. Typical adult size range is 165-190 mm, but they can reach 300 mm and 0.5 kg. Food items range from zooplankton (larvae) to benthic invertebrates (juveniles) to fish for larger adults. The white perch is one of the most abundant species in Chesapeake Bay, and supports significant commercial and recreational fisheries.

Distribution

The white perch is found in brackish water along the eastern seaboard from Nova Scotia south to the Carolinas, and in coastal freshwater ponds and lakes. It is also present in Lake Ontario, which it may have reached through man-made canals. The white perch occurs throughout the upper Chesapeake Bay and tributaries, and in most lower Bay tributaries. This includes essentially the entire Potomac River for adults, and the area from Breton Bay upstream past Washington, including the Washington Aqueduct site, for spawning and nursery activities. They were among the most abundant species captured in the river by DHFWD in 2000, including over 900 individuals collected in Rock Creek.

Habitat Requirements

Adults exhibit schooling behavior and utilize a variety of habitats ranging from areas with substantial structure cover to areas with little or no cover. They may occupy depths up to 9 meters during daylight, but are near the surface (sometimes in schools) during the night. Larvae and juveniles inhabit shallow inshore waters over silt or mud bottoms, sometimes among

vegetation, and in schools. Temperature tolerance varies with population, but Chesapeake Bay white perch typically prefer temperatures between 28 and 31 C. The species generally avoids DO levels less than about 6 mg/L. Egg, larval, and juvenile white perch occupy areas of low salinity, sometimes freshwater. Larvae and juveniles prefer salinities of 1.5 to 3.0 ppt, and adults typically are found in salinities of 5-18 ppt. Laboratory experiments showed that suspended sediment concentrations of 100 to 500 mg/L delayed egg hatching by up to 6 hours, and concentrations of 1,000 mg/L significantly reduced egg hatching success. Suspended sediment concentrations as low as 750 mg/L have been shown to be lethal to larvae. See Section 4.X for a discussion of natural Potomac River total suspended solids (TSS) concentrations. Deposition of sediment on white perch eggs is considered to be more important than suspended sediment. Little is known about the effects of pH on white perch, but some researchers have postulated that pH as low as 6.0 could be harmful.

Spawning

In the Chesapeake Bay, the white perch is semianadromous, moving from the more brackish reaches of the upper Bay and tributaries upstream to spawn in low salinity or freshwater (0-1.5 ppt optimal). Most spawning occurs over fine gravel or sand in less than 6 meters of water. Peak spawning occurs when the water temperature is between 10 and 16 C between mid-March and May (Figure 5-1). Eggs are demersal and attached, or can be pelagic. Hatching occurs between one and six days after fertilization, depending on temperature. The yolk sac larval stage lasts from 4 to 13 days. Based on published growth rates for Potomac River fish in 1987, a total duration of the larval stage was calculated as 41 days (with 19 mm beginning the juvenile stage). The Washington Aqueduct study area is reported to be within the natural spawning area of the species.

5.1.3 American Shad (*Alosa sapidissima*):

General

The American shad is a member of the herring family (Clupeidae), a primarily marine/estuarine group found throughout most of the world. Sexually mature adults may vary between 300 and 500 mm fork length, with a maximum length for the species reported as 760 mm. Young shad in freshwater feed on small crustaceans and insects, and switch to small shrimp after entering saltwater. Adults are planktivorous, feeding on both algae and zooplankton. The species is anadromous, living in the ocean and returning to freshwater solely for spawning. Historically, American shad supported important commercial and recreational fisheries. However, spawning-

stream blockages (dams) and other perturbations in the late 19th and early 20th centuries greatly reduced their numbers. They are currently the subject of intensive restoration programs in the Chesapeake Bay and are under the protection of a 20-year fishing moratorium in Maryland.

Distribution

The American shad is native to the Atlantic coast from Labrador to Florida, and has been successfully introduced on the west coast of the U.S. The species historically spawned in most major tributaries of the Chesapeake Bay, including the Potomac River. Only 15 of 25 Maryland rivers currently have a spawning population of American shad, and most of those are under stress. The Potomac River population is said to be stable but threatened. The reach of the Potomac River from Cobb Island, Maryland upstream to Washington, including the Aqueduct study area, is potential spawning and nursery habitat for American shad.

Habitat Requirements

Owing to their anadromous life style, adult American shad enter the Chesapeake Bay only during the spring for spawning, then return to the ocean. Juveniles spawned in a given year leave the Bay for the ocean primarily from late October through November. Spawning and development of young takes place in relatively shallow, tidal freshwater reaches of tributary streams. Water temperatures between 13 and 26 C are required for development and survival of eggs. Temperatures above 30 C may be detrimental to all life stages. Various studies have demonstrated stress or more serious effects at DO levels below 4 or 5 mg/L. A concentration of 5 mg/L is generally considered a threshold for protection of all life stages. Due to their anadromous life style, American shad are tolerant of a wide range of salinities encountered naturally. Although adults appear to be tolerant of suspended solids, larvae may be sensitive, based on one study documenting reduced larval survival at a suspended solids concentration of 100 mg/L. See Section 4.X for a discussion of natural TSS concentrations in the Potomac River. Based on several laboratory studies, pH values of 6.0 or greater appear to be protective of eggs and larvae.

Spawning

Spawning may takes place anytime between mid-March and early June in Chesapeake Bay tributaries when water temperatures are between 12 and 21 C (Figure 5-1). At any one location, spawning may be of several weeks duration. Spawning takes place primarily in tidal or sometimes non-tidal freshwater in shallow areas with sandy or rocky substrate. Eggs are

semidemersal to pelagic, and hatch in 2 to 17 days, depending on temperature. The yolk-sac larval stage is from 4 to 7 days duration and the post-yolk sac stage lasts 21-28 days. The Washington Aqueduct study area appears to have suitable spawning/nursery habitat for American shad. However, the Potomac River shad population is characterized as a “remnant” population with low abundance. The DHFWD collected only five individuals from the study area in 2000, two of which in excess of 400 mm in length may have been sexually mature.

5.1.4 Blueback Herring (*Alosa aestivalis*):

General

The blueback herring is also a member of the family Clupeidae. Mature adults are 250 mm in length or less, but the maximum recorded size was 380 mm. Apparently, both spawning adults and juveniles feed heavily on zooplankton, and adults may also utilize benthic invertebrates. Although less abundant than in past years, the species supports extensive commercial and recreational fisheries in Chesapeake Bay (harvested as “river herring” along with alewife). Blueback herring runs occur in 22 of 25 tributaries to the Chesapeake Bay, including the Potomac River. The Potomac River population is considered “stable.”

Distribution

The blueback herring is distributed similar to the American shad, along the eastern seaboard from Nova Scotia to Florida. It is present in nearly every Chesapeake Bay tributary, and also utilizes extensive portions of the upper Bay proper as a nursery ground. It was historically common in the Potomac River from the Wicomico River upstream throughout the Washington, DC region, including the Washington Aqueduct region. While the Potomac River runs are currently considered “stable,” certain tributary populations, e.g., Wicomico and Port Tobacco Rivers, are very low in abundance and considered remnant populations.

Habitat Requirements

Adult blueback herring spawn in fresh to slightly brackish water in the upper reaches of Chesapeake Bay tributaries. They tolerate a variety of physical habitats in their spawning reaches. The species is acclimated to the natural temperature regimes of the Bay, but there appears to be an upper limit of about 30 C for protection of young life stages. A DO concentration of at least 5.0 mg/L is considered necessary for protection of juveniles and adults. DO requirements of eggs is not known. All life stages are tolerant of a wide range of salinities.

Egg and larval blueback herring are rather sensitive to pH. Based on laboratory studies, pH values as high as 6.7 had some detrimental effects, depending on aluminum concentrations. Suspended solids concentrations of 1,000 mg/L did not impair egg hatching. Larvae may be more sensitive to suspended solids than eggs, but effects could not be separated from pH in available studies.

Spawning

Adult blueback herring migrate into the low salinity upper reaches of Chesapeake Bay tributaries to spawn. Spawning populations are thought to be discrete for each tributary stream, but some straying of spawning stock may occur. The optimum temperature range for spawning is 21.0 to 25.5 C which, in recent years, equates to the period mid-May into early June (Figure 5-1). Eggs are essentially pelagic, and hatch in 2 to 4 days depending on temperature. The yolk-sac larval stage lasts 2-3 days. The time from hatching to transition to the juvenile stage is unknown, but may be similar to that of the American shad, 25-35 days. The Washington Aqueduct area appears to meet spawning and nursery habitat requirements for blueback herring. In the Aqueduct vicinity, there is a stable remnant population in the Anacostia River. Reports of the species' probable extirpation from Rock Creek (Funderburk et al. 1991) appear inaccurate or dated since 203 individuals were collected from Rock Creek by DHFWD in 2000. An additional 276 individuals were collected from the river in the Aqueduct study area.

5.1.5 Alewife (*Alosa pseudoharengus*):

General

The alewife is also of the family Clupeidae (herrings), and is similar to the blueback herring, with which it is combined in commercial and recreational landings as "river herring." Adult alewives in the Chesapeake Bay average 230-250 mm in length, but can reach 380 mm. Larvae, juveniles, and adults are planktivorous, but adults also feed on benthic invertebrates. Although less abundant than in past years, the species supports extensive commercial and recreational fisheries in Chesapeake Bay (harvested as "river herring" along with blueback herring). The species occurs in 22 of 25 Chesapeake Bay tributary streams, including the Potomac River. The Potomac River runs are reported to be declining.

Distribution

Coastal populations exist from Newfoundland to South Carolina. Landlocked populations have become established in a number of locations including the Great Lakes. The species is common in the mid-Atlantic and Chesapeake Bay. The species distribution in the Bay is virtually identical to that of the blueback herring. The Potomac River contains suitable habitat from the Wicomico River upstream to Little Falls, including the Washington Aqueduct region. A number of discrete tributary populations in the Potomac have declined or disappeared. Near the Washington Aqueduct site, there appears to be a stable remnant population in Rock Creek. This is consistent with the collection of 785 individuals in Rock Creek by DHFWD in 2000.

Habitat Requirements

Alewife utilize the tidal freshwater reaches of Bay tributaries for spawning and development of young. Water temperature is important to all life stages. The majority of eggs in the upper Chesapeake Bay were collected at temperatures between 12 and 14 C. At incubation temperatures below 11 C, the majority of hatched larvae were deformed. Depending on acclimation temperature, upper temperatures as low as 28.4 C resulted in significant egg mortality. The upper temperature tolerance of yolk-sac larvae is about 31 C. Based on several studies, reported preferred and optimum temperatures for juveniles fell between 15 and 23 C. Reported upper lethal temperatures for juveniles and adults at summer acclimation temperatures ranged from 30 to 35 C. Limited data on dissolved oxygen requirements indicate that concentrations of 5 mg/L for eggs and larvae and 3.6 mg/L for juveniles and adults are protective. Mortalities have been observed in the laboratory at DO concentrations of 2.0-3.0 mg/L. Based on the documented locations of spawning and rearing, salinities of 5.0 ppt or less are required. Conversely, juveniles and adults are tolerant of a wide range of salinities. Although some laboratory data suggest no effect of pH 4.5 on young life stages, other tests, which included concentrations of available aluminum, reported mortality at pH 4.5. Based on limited information, it appears that pH ≥ 6.0 are protective. One available study on the effect of suspended solids indicated that concentrations of 50-1,000 mg/L had no effect on egg hatching success. Based on documented spawning sites, physical habitat is not important, except that sluggish flows are preferred.

Spawning

The species spawns in sluggish, tidal freshwater streams over a variety of substrates. They typically travel farther upstream to spawn than blueback herring. Most spawning takes place at

water temperatures between 10 and 22 C. A range of 11.0-19.0 C has been reported for spawning in the Patuxent River. Based on recent Potomac River temperatures, spawning would have taken place between mid-March and early May (Figure 5-1). Eggs are semidemersal to pelagic, and take about 6 days to hatch at 15.6 C. The yolk-sac stage lasts 2-5 days, and the complete transition from hatching to juvenile stage may be similar to the American shad, 25-35 days. The portion of the Potomac River from the Wicomico River upstream to the District of Columbia (including the Washington Aqueduct area) provides suitable spawning and nursery habitat. However, as noted above, the Potomac River alewife runs are in decline. The closest reported for the Aqueduct area is a stable remnant population in Rock Creek. There may be other populations in the vicinity, however. In late March 2000, EA field personnel observed people netting "river herring" from Pimmit Run, a small stream entering the river on the right bank near Chain Bridge. River herring is a collective term for alewife and blueback herring, but, given the time of year, these fish were very likely alewives.

5.1.6 Yellow Perch (*Perca flavescens*):

General

The yellow perch is a member of the perch family (Percidae), which is primarily freshwater, and includes the pikeperches (e.g. walleye, sauger) and darters. The typical adult size range is 152-305 mm total length. Larval yellow perch feed on algae and plankton, and adults feed on a variety of invertebrates and fishes including, in Chesapeake Bay, anchovies, killifish, and silversides. Although much less abundant than in past years, the species continues to support modest commercial and sport fisheries in the Chesapeake Bay.

Distribution

The yellow perch is widely distributed throughout the upper Midwestern U.S. and Canada, and down the eastern seaboard to the Carolinas. Although freshwater, the species has become so acclimated to the brackish water in the Chesapeake Bay that they readily move back and forth between brackish and freshwater on spawning migrations. Most upper Bay rivers contain yellow perch, as do the upper reaches of some lower Bay rivers. The species has been reported in the Potomac River from Washington, D.C. downstream to Breton Bay in St. Mary's County, MD. The species was reported from the project area—both in the river and in Rock Creek—during the year 2000 sampling program by DHFWD.

Habitat Requirements

Adults exhibit schooling behavior and typically inhabit slow-moving near-shore water with some cover, although they may be found at any depth in the Chesapeake Bay rivers. Larvae initially inhabit littoral zones, then migrate offshore into the water column, then back to the littoral zones as juveniles. Water temperatures up to about 30 C are tolerated, with preferred temperatures between 8 and 24 C, depending on life stage. Various levels of dissolved oxygen have been reported as lethal to yellow perch, but 5.0 mg/L is considered a minimum suitable concentration for the species. In the Chesapeake Bay, juvenile and adult yellow perch typically occur at salinities between 5 and 8 parts per thousand (ppt), with an upper limit of about 13 ppt. Spawning takes place in lower salinities, between 0 and 2 ppt. Sediment loading has been shown to affect survival of egg and larval yellow perch. In one study, egg hatching time was delayed 6-12 hours at concentrations up to 500 mg/L suspended sediment, and in another study, that same concentration significantly reduced larval survival after 96 hours. See Section 4.X for a discussion of natural TSS concentrations in the Potomac River. Normal pH levels in Chesapeake Bay are protective of yellow perch, but acid rain runoff in poorly buffered tributaries can be detrimental. A pH of 5.0 appears to be a threshold below which mortality of eggs and larvae is evident.

Spawning

In the Chesapeake Bay, adult yellow perch migrate from downstream tidal reaches into the upper reaches during late winter. Spawning takes place in tidal or non-tidal water with salinities from 0-2.5 ppt. A variety of bottom types is used, including aquatic vegetation. The general spawning temperature range is from 5.0 to 12.8 C, with peak spawning between 8.5 and 11.0 C (Figure 5-1). The peak range is typical of mid-March in most years. Eggs are laid in masses or ribbons on structure such as aquatic vegetation. At peak temperatures, hatching occurs in 20-27 days. The yolk-sac larval stage lasts 3-5 days; no duration was reported for the post yolk-sac larval stage. The Washington Aqueduct area appears to meet the species' requirements for a spawning and nursery area. However, the upstream-most spawning/nursery area has been reported to be downstream of the Aqueduct study area, downstream of the Anacostia River.

5.1.7 Smallmouth Bass (*Micropterus dolomieu*):

General

The smallmouth bass is a member of the sunfish family Centrarchidae. Mature fish may range from under 200 to greater than 400 mm in length. The maximum recorded length was 686 mm. The species is carnivorous throughout its life cycle, cycling from microcrustaceans and insects as fingerlings to crayfish and fish as adults. The smallmouth bass is a freshwater species, only occasionally entering tidal or brackish water.

Distribution

The smallmouth bass was native originally to the Mississippi and Great Lakes drainages in North America. The smallmouth bass, and many other family members have since been transplanted throughout the world, where they are esteemed as sport fish. The species was transplanted to the Atlantic drainages of Virginia, and presumably other mid-Atlantic states, starting in the late 1800s, and has since become widespread in freshwater portions of Chesapeake Bay tributaries. It is primarily an upland species however, and is only occasionally found in tidal freshwater. Sixty-two individuals were collected from the study area in 2000 by DHFWD, or less than one-fifth the number of largemouth bass collected (see below).

Habitat Requirements

The species prefers clear, cool water in streams with some current and riffles, or lakes. Gravel and rock substrates are preferred. Preferred temperatures are reported between 20 and 28 C, and 35 C is reported as an upper lethal temperature. Based on preferred habitat descriptions, the species would be expected to avoid water quality stresses attendant in low dissolved oxygen or pH, or high dissolved solids.

Spawning

The smallmouth bass is a nest-building species that prefers gravel substrate with some current. Silt, clay, and mud substrates are avoided. Spawning takes place in May or June at temperatures between 18 and 27 C (Figure 5-1). Eggs are demersal in the nest and hatch in 2-4 days. As noted above, the species is only an occasional inhabitant of tidal waters, and it is unlikely that any significant spawning activity would take place in the Washington Aqueduct study area.

5.1.8 Pumpkinseed (*Lepomis gibbosus*):

General

The pumpkinseed is another member of the sunfish family Centrarchidae. It is, with the other *Lepomis* species, the classic “sunfish.” They may grow to 100-200 mm with a maximum length of 300 mm. Young fish feed on microcrustaceans and insects and progress with growth to snails, clams, and arthropods.

Distribution

This freshwater species was historically found throughout the eastern seaboard from Canada south to Georgia, the Great Lakes drainage, and the upper Mississippi drainage. It has been transplanted widely, particularly in the northwestern US. It is native to the Chesapeake Bay and is common in tidal and non-tidal freshwater and in brackish water. Based on published distribution records, the species is common in the tidal Potomac River at the District of Columbia and Washington Aqueduct study area. This is consistent with the collection of over 800 individuals from the Aqueduct study area during the DHFWD sampling in 2000.

Habitat Requirements

Pumpkinseed prefer calm water over soft or hard substrates, with cover available, particularly aquatic vegetation. Although technically a freshwater species, they are tolerant of brackish water, and often occur well downstream in tidal rivers at salinities up to 10 ppt, and have been recorded at salinities as high as 18.2 ppt. Pumpkinseed have been reported to tolerate pH levels as low as 4.1.

Spawning

The pumpkinseed builds nests and spawns over a range of temperatures from 13 to 28 C, with the optimum range being 21-24 C (Figure 5-1). Based on Potomac River water temperature data for the last four years, peak spawning occurred in the second half of May. Eggs hatch in 48 hours at temperatures of 19.0 to 25.0 C. Based on spawning habits and requirements, the Washington Aqueduct site likely supports spawning of pumpkinseed.

5.1.9 Bluegill (*Lemomis macrochirus*):

General

The bluegill is another sunfish (Centrarchidae) species, similar in body form and somewhat in coloration to the pumpkinseed. Adult size of the bluegill is quite variable, but is usually between 100 and 200 mm in length (VA populations), with a maximum recorded length of 381 mm. The young are planktivores and adults feed primarily on aquatic and terrestrial insects. The bluegill is common in tidal fresh and brackish waters of the Chesapeake Bay.

Distribution

The bluegill was originally native to the Great Lakes, Mississippi, Gulf of Mexico, and lower Atlantic drainages, but has since been transplanted throughout most of the US and many other countries. The species was transplanted into some Chesapeake Bay drainages, including the Potomac River, by the early 20th century, and perhaps earlier. They are now common in many Bay rivers, and there are a number of collection records from the Potomac River near the District of Columbia. The DHFWD reported collecting 172 individuals from the Aqueduct study area in 2000.

Habitat Requirements

Adult bluegill school in clear, shallow water, often associated with aquatic vegetation. The species is tolerant of high temperatures up to 35 C. The species occupies brackish water in Bay tributaries, tolerating salinities up to 14 ppt. Juveniles school in the limnetic zone, and later move to inshore shallows. The species exhibits a moderate tolerance to low pH. Preferred substrates may be soft or hard.

Spawning

The bluegill builds nests in shallow water and spawns when water temperatures are between 17.0 and 27.0 C, primarily in May and June (Figure 5-1), but can spawn into August. Eggs hatch quickly, in 1.3 days at 22.2-23.3 C. The larval stage lasts 3 to 4 weeks. The habitat at the Washington Aqueduct study area, particularly the shallower, lower velocity areas outside of the channel, could support spawning and nursery activity of bluegill.

5.1.10 Channel Catfish (*Ictalurus punctatus*):

General

The channel catfish is a member of the family Ictaluridae, the freshwater, or bullhead, catfishes. Adults are 300-700 mm in length, with a maximum recorded length of 1,202 mm. Young feed on plankton and aquatic insects and juveniles and adults feed on aquatic invertebrates, fishes, other vertebrates, and some plant material. There is some commercial and recreational fishing for the species in Chesapeake Bay.

Distribution

The original distribution of channel catfish was from Canada to the Gulf of Mexico between the Rocky and Appalachian Mountains, and into Florida. The species has since been widely transplanted, including into Chesapeake Bay tributaries. Currently, the channel catfish exists only in the upper Bay from approximately Back River north, and in the Potomac River from approximately Douglas Point upstream beyond the District of Columbia. The species was rather uncommon in the catches of DHFWD in 2000; only 15 individuals were collected from the river and 24 from Rock Creek in the Aqueduct study area. However, the species may be more abundant than these data indicate because it is relatively difficult to collect with the electrofishing and seine gears used by DHFWD.

Habitat Requirements

The channel catfish prefers deeper water with some current, and tolerates clear to turbid water. The young have a strong schooling tendency, and inhabit shallower water. They are relatively tolerant of high water temperatures; adults prefer 33-34 C. The young are also temperature tolerant, with no developmental or lethal effects below about 35 C. They are tolerant of brackish water, have been found up to 21 ppt, but typically inhabit lower salinities (0-2 ppt). Lethal DO concentrations for juveniles are between 0.76 and 0.96 mg/L at 25-35 C. The species is apparently intolerant of low pH.

Spawning

The channel catfish builds nests in protected cover in waters of 0-2 ppt salinity. Spawning takes place between 21.0 and 29.0 C, with 27.0 C being the optimum, from May through July (Figure 5-1). Demersal eggs are laid in the nest in gelatinous masses and take 5 to 10 days to

hatch. Spawning of channel catfish in the Potomac River at the Washington Aqueduct site is probably common.

5.1.11 Brown Bullhead (*Ameiurus nebulosus*):

General

The brown bullhead is in the family Ictaluridae with the channel catfish and other allied species. Adults are 140-340 mm standard length and the maximum length recorded was 508 mm. The omnivorous brown bullhead eats microcrustaceans as young, and various invertebrates, algae, and fish as adults.

Distribution

The brown bullhead is native to the Atlantic, Gulf, Mississippi, and Great Lakes drainages, and has been transplanted widely. The species is resident in freshwater and tidal brackish reaches of every Chesapeake Bay tributary, and is generally distributed in the upper Bay proper from Back River north. Potomac River records are numerous from Douglas Point upstream to beyond the District of Columbia. The DHFWD reported collecting 772 individuals from the Potomac and Anacostia Rivers at Washington, D.C., but only 26 of these were from the Aqueduct study area.

Habitat Requirements

The brown bullhead commonly inhabits shallow, muddy waters, and stays close to the bottom substrate. The species likes warm water and can survive temperatures up to 36 C with proper acclimation. It is tolerant of brackish water up to 8-10 ppt salinity. It may be relatively tolerant of low DO; one study reported a lower lethal level of 0.2 mg/L at low temperatures. Based on Virginia records, the species is somewhat tolerant of low pH.

Spawning

Nests are excavated, and spawning takes place between 21.0 and 25.0 C in the late spring in Maryland (Figure 5-1). Eggs hatch in 5 to 7 days. Parental protection is provided for the schooling young for some weeks before dispersal. Spawning is likely in the area of the Washington Aqueduct.

5.1.12 Shortnose Sturgeon (*Acipenser brevirostrum*):

General

The shortnose sturgeon belongs to the ancient family Acipenseridae. Although small for sturgeon, it is a relatively large fish that can grow to over four feet in length and 16.5 kg (36 lb), although most individuals encountered are not this large. It is a long-lived species, with one female reported to have lived 67 years. The species is adapted for benthic feeding and reportedly eats a variety of worms, mollusks, and crustaceans. The shortnose sturgeon is quite rare, and is a Federally-listed endangered species. It is the focus of intensive Federal and state search and monitoring efforts to determine its status in the Chesapeake Bay and tributaries.

Distribution

The historical distribution of the shortnose sturgeon was along the eastern seaboard from the St. Johns River in New Brunswick to the St. Johns River in Florida. Jenkins (1994) cited one valid record of the species in the Chesapeake Bay drainage prior to 1900 (Potomac River at Washington). The species was not again encountered in the Chesapeake Bay area until the 1970s. In 1996, the U.S. Fish and Wildlife Service initiated a Reward Program for reporting of incidental catches of shortnose sturgeon in commercial fishing gear. Approximately 30 specimens have been reported in that program, primarily north of the Bay Bridge. The species has not been documented in the Aqueduct project area. However, resource agency personnel have expressed concern that the shortnose sturgeon may overwinter in the deep channels in the project area (D.C. DHFWD 2001, personal communication).

Habitat Requirements

Little is known about the specific habitat requirements of the shortnose sturgeon. It is found most often in tidal rivers, but may occur from freshwater to the ocean. What is known of the species' life history suggests that deep, turbulent freshwater portions of tidal rivers may be required for spawning, and lower, more brackish reaches of tidal estuaries for overwintering. Juveniles typically inhabit deep river channels upstream of the salt wedge. Pollution, and consequent reduced dissolved oxygen concentrations, has been frequently cited as one possible reason for the disappearance of the species from many rivers. The species' requirements in terms of water quality may be similar to the other species discussed in this document.

Spawning

Shortnose sturgeon are slow to mature, and may take from two to 13 years depending on latitude. Age at first spawning may be anywhere from one to 16 years following maturation. Following initial spawning, they may not spawn again for one to 10 years. Spawning takes place from winter into summer, depending on latitude. A range of 9-12 C is cited as the spawning temperature, which would typically be in March in the Potomac River (Figure 5-1). Newly hatched larvae drift with the current until quiet areas are reached where the yolk sac is absorbed and feeding is initiated.

5.2 POTENTIAL FISH HABITAT IN THE PROJECT AREA

The area of the Potomac River from the Dalecarlia Reservoir Outfall 002 downstream to Theodore Roosevelt Island reflects a variety of aquatic habitats because it is a transition zone. In May 2000, EA scientists floated the entire Aqueduct study reach and recorded qualitative observations of available habitat. Particular note was made of substrate type, submerged and emergent aquatic vegetation, and current. Habitat data and photographs were superimposed on a USGS quad of the study area that was geo-referenced within Autocadd. The resulting Figure 5-2 is included at the end of this report.

At the very upper end of the project area near Outfall 002, the channel is very constricted with turbulent flow over boulder substrate (Figure 5-2). Going downstream, the river gradually widens and deepens, and flow velocities diminish. The widest areas are at the lower end of the project area, just upstream of Theodore Roosevelt Island (~1,000-1,500 ft.). Maximum depths in the project area vary from about 12-ft (MLW) just above Outfall 002 to nearly 60-ft in channel areas near the middle of the project area. Depths tend to be shallower in the lower portion of the project area, although there are a few small pockets of nearly 60-ft deep water. Silt and sand substrates are found in nearshore areas and embayments, particularly in the lower portion of the project area where currents are slower. Submerged aquatic vegetation (SAV) exists in some of the more sheltered nearshore and embayment areas, and is more prevalent in the downstream portion.

In an earlier study of the sediment discharges from the Dalecarlia and Georgetown Reservoirs, Dynamac Corporation (1992) concluded that *bottom sediments are apparently being continually redistributed* by storm-flow/scour events. This creates a very dynamic and generally poor environment for the benthic fauna.

Based on the habitat conditions in the project area, and inferences on the status of the food base from Dynamac Corporation (1992), portions of the area may not be considered high quality fish habitat. The turbulent flows in the upper portion of the project area would preclude use by some species, particularly the sunfishes that prefer quieter water. The dynamic and generally poor benthic fauna described by Dynamac Corporation (1992) would represent a poor food base for some adults and most young of the fish species of concern evaluated. Spawning and nursery activity is likely restricted to those nearshore and embayment areas with finer sediment and some cover such as SAV.

Although portions of the Aqueduct study area appears to represent marginal habitat to some degree, a more appropriate test of habitat value is the degree to which it is utilized by various fish species. Based on the fisheries collections made by the DHFWD in 2000, the area supports (at least during part of the year) a variety of fish species. Thirty-nine species were recorded during 2000, a number of which were common or abundant, including white perch, largemouth bass, alewife, blueback herring, yellow perch, and pumpkinseed. Thus, the available habitat is sufficient to support a relatively diverse and abundant fish community.

5.3 POTENTIAL FOR SEDIMENT-DISCHARGE IMPACTS TO FISH SPECIES OF CONCERN

Potential impacts would be primarily restricted to young life stages of some of the fish species of concern. Juvenile and adult fish are mobile, and would be expected to avoid the discharges if stressed. Larvae and, particularly eggs, would be unable to avoid the sediment plume in the discharge areas. Common species that may spawn in the river include white perch, largemouth bass, pumpkinseed, and, potentially, striped bass. River spawning by alewife, blueback herring, and yellow perch cannot be ruled out, but they are more likely to spawn in Rock Creek. American shad are reported in very low abundance in the river (Klauda et al. 1991), and this makes them particularly vulnerable because they could theoretically spawn in the project area.

The risks to young life stages of fish from the discharges are suspended solids—either in the water column or deposited on the substrate—and elevated aluminum concentrations. Based on literature observations of the effect of suspended solids on fish eggs and larvae (Section 5.1 above), exposure to 100 mg/L appears to be a threshold for effects on some species. This concentration was reported to delay egg hatching in white perch (Setzler-Hamilton 1991) and reduce larval survival in American shad (Klauda et al. 1991). Based on the modeled TSS concentrations during discharge events (Figures 2.3-2 to 2.3-4 and 2.3-7 to 2.3-9), suspended sediment concentrations in the water column exceed the 100 mg/L threshold only very near the

discharges. The modeled discharge point concentration of 10,000 mg/L TSS is rapidly diluted such that TSS concentration at Dalecarlia Outfall 002 is below 100 mg/L virtually just beyond the discharge point (Figure 2.3-2). At the Georgetown Outfall 003, the 100 mg/L contour extends downstream about 300 meters (Figure 2.3-7). The elevated TSS concentrations are relatively short lived. Whereas the TSS plume configuration illustrated in Figure 2.3-7 reflects conditions during an approximate 3.5-hour discharge event, within two hours of discharge cessation, all river TSS concentrations are below 100 mg/L (Figure 2.3-8). The small areas of the river involved and short duration of the events should preclude significant impacts on fish or other aquatic organisms from suspended sediment.

Deposition of solids on the bottom may be more important than suspended sediment. The modeling results in Section 2. project some deposition of sediment in the river following the discharges. During spring discharges, incubating eggs that are covered by sediment may be subjected to reduced dissolved oxygen and potentially suffer mortality. The rapid decrease in TSS concentrations downstream of the discharges, evident in the above-referenced figures, is evidence of deposition. Consequently, it is concluded that the bulk of suspended solids fall to the substrate within a reasonably small area near the discharge. Fish eggs or larvae in this area would be at risk due to smothering and reduced dissolved oxygen. However, the area potentially affected represents a small portion of the Aqueduct study area.

Exposure of fish eggs and larvae to aluminum must be considered as a short-duration exposure, since the discharges are flushed through and out of the project area in no more than one-half day. The aluminum criteria document (U.S. EPA 1988) lists LC₅₀ concentrations for several fish species ranging from 3,600 to 50,000 µg/L. During a typical 3.5-hour discharge event, such concentrations will exist in a small area for a short period of time. There are several important points to be made when making comparisons between field exposure and laboratory “effects values.”

- The LC₅₀ values for fish are based on 96 hour continuous exposure to a given concentration (e.g., 3,600 µg/L), whereas exposure to elevated concentrations in the river during a discharge event are expected to last for only a few hours.
- The laboratory experiments which generated these LC₅₀ values used laboratory grade aluminum (i.e., dissolved aluminum), whereas the aluminum in the river is dominated by substantially less toxic forms of the metal measured as “total aluminum.”

In Section 2., a strong correlation was established between TSS concentrations and total aluminum concentrations. Consequently, using the same TSS model relationships discussed above, and assuming a relatively conservative discharge concentration of total aluminum of 1,500,000 µg/L (Table 2.1-5), a reach of river of approximately 900 meters below the Georgetown Outfall 003 and a very small reach in the immediate vicinity of the Dalecarlia Outfall 003 will exceed the 3,600 µg/L LC₅₀ concentration during discharge events. As with TSS concentrations, total aluminum concentrations will rapidly decrease with cessation of discharges. In addition, EPA (1999) has indicated that the dissolved form of metals is most appropriate for determining risk to aquatic organisms. Since dissolved aluminum concentrations measured in the project area were about 15 percent of total concentrations, it is very unlikely that any toxicity would be expressed beyond the immediate vicinity of the Dalecarlia Outfall 002 or beyond 300-400 meters below the Georgetown Outfall 003. Again, river concentrations will be quickly reduced to ambient, or background levels at the conclusion of the approximately 3.5-hour discharge event.

Another perspective on the potential toxicity of aluminum in the Aqueduct discharges is provided by the whole effluent toxicity testing program discussed in Section 3. of this report. Based on 48- and 96-hour testing using fathead minnows and water fleas (*Daphnia magna*), the Aqueduct effluents were not acutely toxic (LC₅₀ values > 100 percent effluent).

In summary, there appears to be moderate risk to several fish species of concern from sediment discharges from the project reservoirs when young life stages are present. The primary risk is from deposition of suspended sediment on eggs and larvae, which could affect survival.

5.4 POTENTIAL DISCHARGE MANAGEMENT SCENARIOS TO MINIMIZE IMPACTS TO FISH SPECIES OF CONCERN

As described elsewhere in this report, discharges of sediment from the Dalecarlia and Georgetown Reservoirs are restricted by the NPDES permit to periods when the river flow is equal to or greater than 3.5 billion gallons per day (5,415 cubic feet per second [cfs]), or when the turbidity of the receiving water is equal to or greater than 100 NTU. Presumably, this restriction was incorporated to ensure that sediment discharges took place when the natural sediment load in the river was high, dispersion was quicker, and visual impacts least. On a practical basis, these restrictions have meant that discharges may take place in the spring when the flow/turbidity requirements are more likely. For example, the flow threshold is exceeded 90-95 percent of the time during March-May, but only 15-25 percent of the time during July-Oct.

Notwithstanding the greater probability of acceptable river flows during the spring months, recent operational history indicates that discharges take place primarily during non-spring months. During the calendar years 1996 and 1997, there were 29 discharge events among all of the Dalecarlia and Georgetown basins. Only nine of these (31 percent) took place during spring months (March-May).

There has been growing concern among resource agencies because spring discharges take place during the most biologically sensitive period when fish spawning takes place and young life stages are present. This is clearly illustrated in Figure 5-1, discussed earlier, which shows the spawning periods of species of concern covering the period March into June, or even July. Concern over the potential impacts of sediment discharges on fish and other aquatic resources was most recently discussed by a panel of resource agency personnel (Sutherland 1999). This panel recommended, among other things, that no sediment discharges be made between February 15 and June 15 to protect the important fish spawning period.

After thorough review of the biological issues, as well as the operational needs of the Washington Aqueduct facility, we provide the following recommendations for alterations to the discharge management protocols.

1. Reduce the flow threshold (below which discharges cannot take place) by 20 percent.

The new threshold flow would become 2.8 billion gallons per day (4,322 cfs). This would increase the probability of having flows acceptable for discharge by 5 to 10 percent in nearly all months. Such a change would ease the effect of other restrictions (see below) to provide protection during critical biological periods. This would require a revision to the current flow reduction in the NPDES permit.

2. Eliminate discharges between 15 February and 15 June.

This recognizes the importance of this period for critical spawning and nursery activity of fish species of concern in the tidal Potomac River in the vicinity of the Aqueduct.

3. Discharge more slowly using more dilution water.

Observations of Aqueduct cleaning and discharges suggest that the cleaning of each basin could occur more slowly (e.g., over 5 hours instead of 3 hours), and more water could be used during

each cleaning such that discharge concentrations of TSS and aluminum might be substantially lower than the current condition (e.g., 3-10 times more dilute).

4. Negotiate an agreement with the EPA and pertinent resource agencies to allow discharges during the spring on an emergency basis.

With revisions to the discharge protocols as described in recommendations 1., 2., 3., and 4. above, the likelihood of a need to discharge during the spring period would be substantially reduced. However, there must be a mechanism whereby a discharge could take place during the spring period on an emergency need basis. This could be a repair situation, or anything that could threaten stable delivery of the potable water from the Washington Aqueduct.

5.5 REFERENCES

- Cooper, J., R. Eades, R. Klauda, and J. Loesch (eds.). 1994. *Anadromous Alosa Symposium*. Tidewater Chapter American Fisheries Society, Bethesda, MD.
- D.C. Department of Health Fish and Wildlife Division (DHFWD). 2001. Personal communication, J. Siemien.
- Dynamac Corporation. 1992. *Impacts of Sedimentation Basin Discharges from the Dalecarlia and Georgetown Reservoirs on the Potomac River*. Prepared for U.S. Army Corps of Engineers, Baltimore District. Dynamac Corp., Rockville, MD.
- Funderburk, S., J. Mihursky, S. Jordan, and D. Riley (eds.). 1991. *Habitat Requirements for Chesapeake Bay Living Resources*. Second Edition. Chesapeake Research Consortium, Inc., Solomons, MD.
- Jenkins, R. and N. Burkhead. 1994. *Freshwater Fishes of Virginia*. American Fisheries Society, Bethesda, MD.
- Klauda, R., S. Fischer, L. Hall, Jr., and J. Sullivan. 1991. American Shad and Hickory Shad, pp. 9-1 to 9-27 in: *Habitat Requirements for Chesapeake Bay Living Resources* (S. Funderburk, S. Jordan, J. Mihursky, and D. Riley, eds.). Second addition. Chesapeake Research Consortium, Inc., Solomons, MD.

- Lee, D., C. Gilbert, C. Hocutt, R. Jenkins, D. McAllister, and J. Stauffer, Jr. (eds.). 1980. *Atlas of North American Freshwater Fishes*. N. C. State Mus. Nat. Hist., Raleigh, NC.
- Lippson, A. 1973. *The Chesapeake Bay in Maryland: An Atlas of Natural Resources*. The Johns Hopkins University Press, Baltimore, MD.
- Lippson, A. and R. Lippson. 1984. *Life in the Chesapeake Bay*. The Johns Hopkins University Press, Baltimore, MD.
- Setzler-Hamilton, E. 1991. White Perch, pp. 12-1 to 12-20 in: *Habitat Requirements for Chesapeake Bay Living Resources* (S. Funderburk, S. Jordan, J. Mihursky, and D. Riley, eds.). Second addition. Chesapeake Research Consortium, Inc., Solomons, MD.
- Sutherland, D. 1999. *Washington Aqueduct Sediment Discharges Report of Panel Recommendations*. U.S. Fish and Wildlife Service Chesapeake Bay Field Office, Annapolis, MD. <http://www.nwi.org/SpecialStudies/WashConsProject/AquReport.html>.
- U.S. EPA. 1999. *National Recommended Water Quality Criteria—Correction*. Office of Water, Washington, DC. EPA 822-Z-99-001. April.
- U.S. EPA. 1988. *Ambient Water Quality Criteria for Aluminum – 1988*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. PB-88-245998.
- U.S. Fish and Wildlife Service. 1978. *Development of Fishes of the Mid-Atlantic Bight: An Atlas of Egg, Larval and Juvenile Stages*. FWS/OBS-78/12. Six volumes.

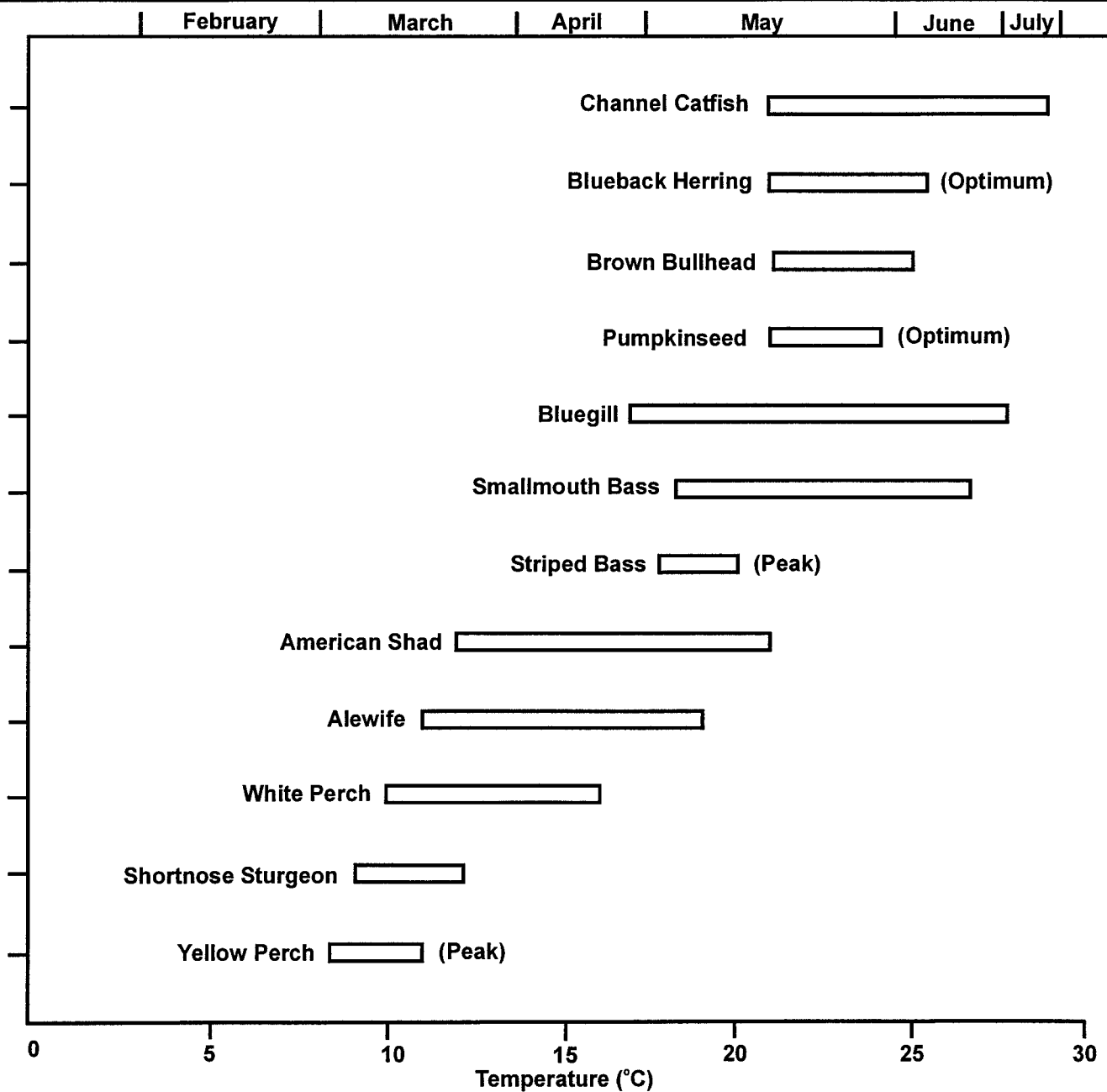


Figure 5-1. Spawning Periods for Fish Species of Concern
(Date-Temperature Relationship Based on Mean Potomac River Temperatures for the Period 1996-1999).